

Chapter Ten – Flood Design Criteria for New Growth Areas

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10.1 Floodplain Management

10.1.1 Definitions

1-year Flood

The flood typically occurring or being exceeded in any given year.

2-Year Flood

The flood having a fifty percent chance of being equaled or exceeded in any given year.

5-Year Flood

The flood having a twenty percent chance of being equaled or exceeded in any given year.

10-Year Flood

The flood having a ten percent chance of being equaled or exceeded in any given year.

100-Year Flood

The flood having a one percent chance of being equaled or exceeded in any given year.

Base Flood

The flood having a one percent chance of being equaled or exceeded in any given year.

Compensatory Storage

Replacement of storage volume that is hydrologically equivalent to lost storage when encroachment occurs in the floodplain or floodprone area.

Existing Urban Area

Those areas inside the corporate limits of the City of Lincoln, as well as those areas outside the corporate limits having a zoning designation other than AG Agriculture and AGR Agricultural Residential, as defined by the Lincoln Municipal Code.

FEMA

The Federal Emergency Management Agency.

Flood Fringe

That portion of the floodplain which is outside of the floodway

Flood Insurance Rate Map (FIRM)

Flood Insurance Rate Map (FIRM) shall mean the September 21, 2001 Flood Insurance Rate Map and any revisions thereto, on which FEMA has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

Floodplain

Those lands which are subject to a one percent or greater chance of flooding in any given year, as shown on the Flood Insurance Rate Map (FIRM) issued by FEMA for Lancaster County, Nebraska and incorporated areas, as amended.

Floodprone Area

Those lands which are subject to a one percent or greater chance of flooding in any given year, as determined by hydrologic and hydraulic studies completed by the City or other government agency, or other acceptable source as approved by the City where this is the best available information.

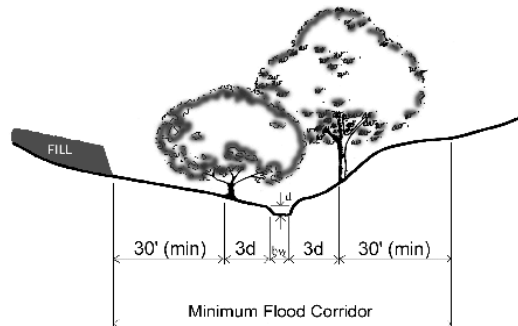
Floodway

The channel of a river or other watercourses and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

Minimum Flood Corridor

Minimum flood corridor shall mean the existing channel bottom width plus 60 feet plus 6 times the channel depth and the corridor will be centered on the channel, as shown in Figure 10-1 below, or aligned such that the corridor follows the natural flow of flood waters. For streams with a defined bed and bank which drain less than 150 acres, Minimum Flood Corridor shall mean a narrower corridor proportionate to the drainage area as identified in the City of Lincoln Design Standards.

Figure 10-1: Minimum Flood Corridor



New Growth Areas

Those areas outside the corporate limits of the City of Lincoln and zoned AG Agriculture and AGR Agricultural Residential as defined by the Lincoln Municipal Code.

Stream Crossing Structures

Structures used to convey pedestrians, motor vehicles, and/or utilities across drainageways. Stream crossing structures are composed of the structure, abutments, guard rails, fill, and other structural appurtenances that are generally perpendicular to the conveyance of flow within the floodplain or floodprone area.

Watershed Master Plan

A plan generated by the City or by the City in cooperation with other agencies, which includes hydrologic and hydraulic modeling for the base flood event, including floodplain elevation and limits.

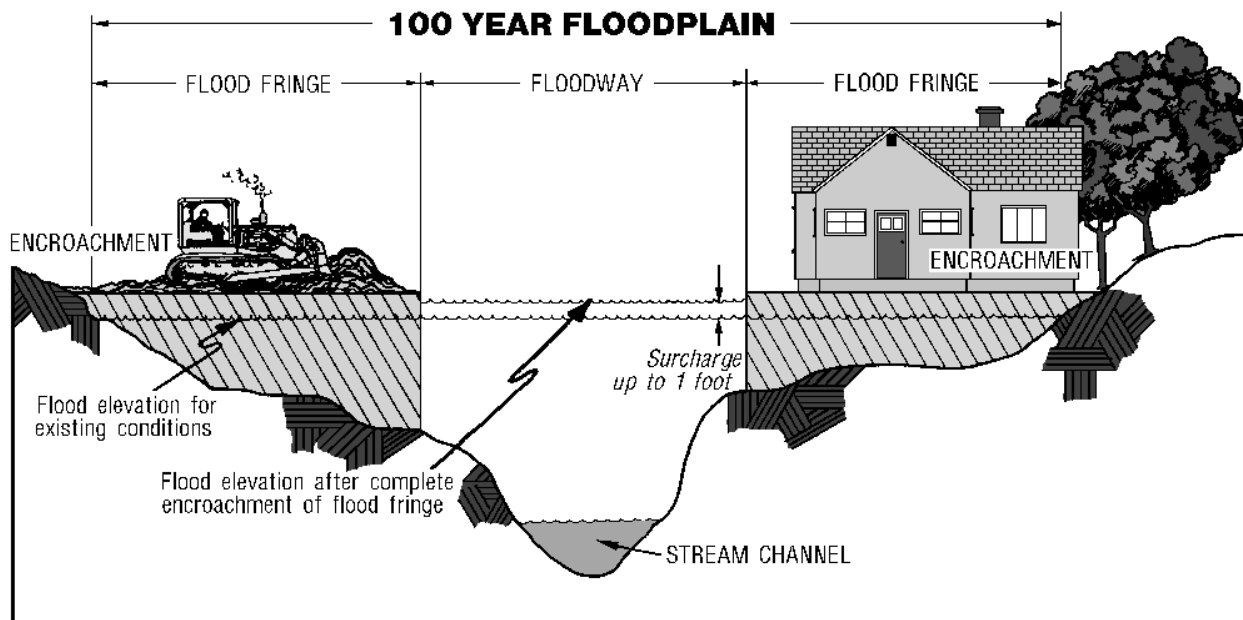
10.1.2 National Flood Insurance Program (NFIP)

The NFIP was established by the U.S. Congress on August 1, 1968 as a means to reduce future flood damage through individual community floodplain management ordinances and to provide protection to property owners against potential losses by offering flood insurance. If a community chooses to participate in the NFIP, the community must adopt and enforce a floodplain management ordinance that meets minimum requirements of the NFIP. However, communities are encouraged to adopt higher floodplain management standards. The NFIP's Community Rating System (CRS) recognizes communities that adopt standards or programs which exceed minimum requirements by reducing flood insurance premium rates for property owners in the community.

10.1.3 Minimum FEMA Floodplain Requirements

FEMA divides the floodplain into two zones: the floodway and the flood fringe, as shown in Figure 10-2. Minimum federal floodplain standards require that no fill or obstructions be placed in the floodway unless it is demonstrated (by means of hydraulic modeling) that the proposed fill will not cause any increase in the water surface elevation of the floodway profile.

Figure 10-2: FEMA Floodway and Flood Fringe



*schematic from The Nebraska Department of Natural Resources

10.1.4 Scope of Flood Design Criteria for New Growth Areas

The City of Lincoln has adopted standards for floodplain and floodprone areas in New Growth Areas that exceed the minimum federal standards. The following sections provide information on Flood Design Criteria for floodplains and floodprone areas within the New Growth Areas. As an umbrella policy for flood management in New Growth Areas, the City of Lincoln has adopted a No Adverse Impact (NAI) policy, which is a managing principal with a goal of ensuring that the action of one property owner does not adversely impact the flooding risk for other properties, as measured by increased flood stages, flood velocity, flows or the increased potential for erosion and sedimentation.

The following design criteria have been prepared to guide the design and construction of structures and development within the floodplain and floodprone areas. There are three major design criteria required for flood management in New Growth Areas: 1) No Net Rise, 2) Compensatory Storage, and 3) Minimum Flood Corridor protection. In general, the No Net Rise and Compensatory Storage criteria relate predominantly to 'water quantity' issues, while the Minimum Flood Corridor criterion relates predominantly to 'water quality' issues.

In addition to the flood design standards required by this chapter, Section 10.5 also includes recommended standards for floodplains and floodprone areas. These are recommended standards for the use of 'best management practices' (BMPs) which can provide additional protection and enhancement of the natural and beneficial functions of the floodplain/floodprone area.

10.2 No Net Rise and Compensatory Storage

10.2.1 Overview

'No Net Rise' and 'Compensatory Storage' are two criteria which together address the 'water quantity' functions of the floodplain and floodprone areas. No Net Rise relates to the conveyance properties of the floodplain, or 'how the water flows,' while Compensatory Storage relates to the volume, or 'how much total water there is.' The purpose for coupling No Net Rise with Compensatory Storage in a single standard is to address conveyance of floodwater along the watercourse, and at the same time to insure that the amount of water reaching the water course does not increase. A No Net Rise standard by itself would preserve conveyance, but would not regulate 'non-conveyance' areas - backwater areas which contribute to the flood reducing characteristics of the floodplain and floodprone areas. The No Net Rise standard by itself would also not address increases in water velocity or stream erosion. Alternatively, if only a Compensatory Storage standard were adopted, hydraulic conveyance would not be preserved, and there could be a rise in flood heights.

Documentation by a Professional Engineer is required to show that compensatory storage and no net rise criteria are met, per Section 10.5 of this Chapter. Exceptions and flexibility for meeting criteria are provided for specified cases (e.g. crossings, dams, minor utility/street work) as detailed in subsequent sections of this Manual.

10.2.2 No Net Rise

10.2.2.1 Overview

The No Net Rise criterion relates to the first of the two fundamental 'water quantity' functions of the floodplain: flood water conveyance, or 'how the water flows.' No Net Rise means that development within the floodplain or floodprone area is required to demonstrate through an engineering study that it will cause no increase in the water surface elevation of the 100-year flood greater than five hundredths of a foot (0.05').

10.2.2.2 Floodways

No net rise within the floodway means that the development will cause no increase (0.00 feet rise) in the water surface elevation of the 100-year flood.

10.2.2.3 Floodplain or Floodprone Area With No Watershed Master Plan

For floodplains or floodprone areas having no Watershed Master Plan, documentation by a professional engineer is required to show that the development will cause no increase in the water surface elevation of the 100-

year flood greater than five hundredths of a foot (0.05'). This shall be demonstrated using current FEMA models. If there is no FEMA model available, a City approved hydraulic model will need to be developed.

10.2.2.4 Floodplain or Floodprone Area With a Watershed Master Plan

For floodplains or floodprone areas with Watershed Master Plans, documentation by a professional engineer is required to show that the development will cause no increase in the water surface elevations of the 2-, 10-, and 100-year flood events greater than five hundredths of a foot (0.05'). This shall be demonstrated using the hydraulic models developed by the City or by the City in cooperation with other agencies for Watershed Master Planned areas.

10.2.2.5 Limits of Modeling

Hydraulic conditions within, and both upstream and downstream of the project area shall be evaluated along the channel to the point where water surface profiles consistently meet the existing conditions.

10.2.3 Compensatory Storage

10.2.3.1 Overview

The Compensatory Storage criterion relates to the second of the two fundamental 'water quantity' functions of the floodplain: flood storage volume, or 'how much total water there is.' Compensatory Storage within the floodplain or floodprone area means that encroachments of structures or fill which cause a loss of flood storage are offset by providing a hydrologically equivalent volume of storage adjacent to the area of the encroachment. A hydrologic study can be used but is not required to demonstrate that the storage is hydrologically equivalent, except where a hydrologic model has been developed for a Watershed Master Plan. However, compensatory storage shall be provided with the objective of being hydrologically similar to lost flood storage volume.

10.2.3.2 Compensatory Storage without Hydrologic Study

This alternative may be used for areas where no Watershed Master Plan has been completed. Specifically, compensatory storage must meet the criteria shown below:

- Compensatory storage must be provided at a ratio of 1 to 1 or greater for fill that is proposed in the floodplain or floodprone area outside of a minimum flood corridor.
- Compensatory storage must be provided at a ratio of 1.5 to 1 for encroachments within the minimum flood corridor.
- Flood storage lost below the existing 10-year flood elevation must be compensated for below the proposed 10-year flood elevation. Flood storage lost above the existing 10-year flood elevation must be compensated for above the proposed 10-year flood elevation.
- Compensatory storage areas shall be graded to freely drain back to the stream.
- Compensatory storage shall be opposite or adjacent to areas filled, occupied, or otherwise encroached upon.
- The entire compensatory storage area shall be preserved and through the dedication of an easement in conformance with Section 26.23.120 of the Lincoln Municipal Codes.

- Fill placed next to the minimum flood corridor in a floodplain or floodprone area will be graded at a 4:1 horizontal on to vertical slope or flatter. Silt fence must be placed a minimum 6 feet from the toe of the fill, outside the minimum flood corridor to protect soil erosion from entering the area.

10.2.3.3 Compensatory Storage with Hydrologic Study

A hydrologic study is required in areas where a Watershed Master Plan has been completed and is an option for areas where a Watershed Master Plan has not been completed.

Compensatory storage shall be evaluated in Watershed Master Plan areas using the hydrologic models developed by the City or by the City in cooperation with other agencies. Compensatory storage shall be demonstrated by showing that post encroachment peak flow rates do not exceed pre-encroachment flow rates for the for the 2-, 10- and 100-year storm events.

Compensatory storage for areas where a Watershed Master Plan has not been completed may be evaluated using a hydrologic model acceptable to the City. Compensatory storage shall be demonstrated by showing that post encroachment peak flow rates do not exceed pre-encroachment flow rates for the for the 100-year storm event.

10.2.3.4 Limits of Modeling

Hydrologic conditions both upstream and downstream of the project area shall be evaluated along the channel to the point where stream flows consistently meet the existing conditions.

10.2.4 Exceptions

Certain exceptions are provided to the no net rise and compensatory storage criteria for the following:

10.2.4.1 Residential Non-Substantial Improvements

Residential non-substantial improvements are not required to meet no net rise and compensatory storage criteria. Non-substantial improvements are defined in Chapters 27.52 and 27.53 of the Zoning Ordinance.

10.2.4.2 Stream Crossing Structures

Stream crossing structures meeting the conditions for sequencing and mitigation provided in Section 10.4 of this Manual are allowed certain exceptions from the no net rise and compensatory storage criteria.

10.2.4.3 Minor Projects

Minor projects clearly having negligible impact, such as street resurfacing and rehabilitation, certain utility infrastructure and appurtenances (e.g. hydrants, poles, manholes, underground pipes), bridge/culvert rehabilitation projects, landscaping, stream rehabilitation, and minor water quality features which typically pose no increased fill or flood potential that would cause a rise over 0.05 feet are not required to submit study information to document no net rise and compensatory storage unless specifically required by the Director of Public Works and Utilities. However, certification must be provided by a professional engineer that the project will cause no rise in the floodway, and no rise greater than 0.05' outside the floodway in the floodplain or floodprone area.

10.2.4.4 Approved Preliminary Plats

Development pursuant to approved preliminary plats which are still in force on the effective date of these standards is not required to meet no net rise and compensatory storage criteria.

10.2.4.5 Public Stream Crossing Structures

Public stream crossing structures which have had a design public hearing or have an approved environmental assessment, environmental impact statement, or Class II justification on the effective date of these standards are not required to meet no net rise and compensatory storage criteria.

10.2.4.6 Dams and Other Stormwater Storage Structures

Dams, road attenuation structures, stormwater detention/retention facilities, ponds, stream stability structures, wetlands and other water quality features are not required to meet no net rise and compensatory storage criteria. Dams and road attenuation structures must meet design criteria identified in this manual for hydraulic structures, minimum state and federal floodplain requirements, and, if applicable, standards for dams required by the state of Nebraska. Furthermore, increases in flood heights greater than 0.05 feet for the 100-year flood must be mitigated by 1) Acquisition by land rights purchase, flowage easement, or other legal arrangement that runs with the property granting the right to increase the flood levels on all affected lands, and restricting that portion of the property from future development, or 2) Mapping change through FEMA Letter of Map Revision process.

10.2.4.7 Minimum Federal Standards

Notwithstanding the exceptions allowed by this section, within FEMA mapped floodplains the following minimum federal standards must still be met:

1. Within designated floodways, minimum federal regulations do not allow any rise per sections 27.52.030(h) and 27.53.030(h) of the zoning ordinance, unless land rights are acquired, a conditional letter of map revision is first approved by FEMA, and an approved letter of map revision is provided after the project is completed.
2. Within the flood fringe where no floodway has been designated (Zone A), federal standards prohibit any rise greater than one foot (1.0'), per sections 27.52.030(a)(1) and 27.53.030(a)(2) of the zoning ordinance, unless land rights are acquired, a conditional letter of map revision is first approved by FEMA, and an approved letter of map revision is provided after the project is completed.

10.3 Minimum Flood Corridor

10.3.1 Description

In New Growth Areas, the preservation of a Minimum Flood Corridor is required along all channels which drain greater than 150 acres or have a defined bed and bank (See Figure 10-1). The width of minimum flood corridors shall be equal to the channel bottom width, plus 60 feet, plus six times the channel depth, and the corridor shall be centered on the channel or aligned such that the corridor follows the natural flow of flood waters. For streams with a defined bed and bank which drain 26 to 150 acres, the width of minimum flood corridors shall be equal to the channel bottom width, plus six times the channel depth, plus:

- i. 40 feet, for channels draining 101 to 150 acres;
- ii. 20 feet, for channels draining 51 to 100 acres;
- iii. 10 feet, for channels draining 26 to 50 acres;

10.3.2 Sequencing Criteria for Minimum Flood Corridors

Riparian vegetation and the existing grade within the identified flood corridors shall be preserved or enhanced to the maximum extent practicable, or mitigated during the development planning and construction processes when impacted by allowable encroachments. Individual areas of encroachments into the riparian vegetation and encroachments of fill into the existing grade will be permitted for operation, maintenance and repair, channel improvements, stormwater storage facilities, and utility crossings. Individual areas of encroachments may also be permitted for parks, pedestrian/bike trails, recreational uses, and public purposes, provided the encroachments are minimal and the uses are generally consistent with the purpose of the corridor. Prior to allowing vegetative encroachments or fill for permitted purposes into the minimum flood corridor, a sequencing process will be required which first seeks to avoid, then to minimize, then mitigate for impacts to the minimum flood corridor.

Documentation must be submitted to the City for review showing the steps taken using the sequencing approach, and the selected alternative. The sequencing process shall include an evaluation of alternative approaches in the order listed below:

1. Avoidance. Encroachment of riparian vegetation and the existing grade should be avoided if there is a practicable alternative that does not cause encroachment.
2. Minimization. If it is determined that avoidance is not practicable then steps must be taken to minimize impacts to the riparian vegetation and/or the existing grade.
3. Mitigation. Impacts to the riparian vegetation or to the existing grade must be mitigated after an appropriate and feasible alternative has been chosen through minimization.

Mitigation for loss of riparian vegetation in impacted areas shall occur at a 1.5 to 1 ratio. Where land uses prior to development have an impact on the buffer, the area should be replanted with vegetation compatible with the minimum flood corridor and water quality benefits.

Mitigation for fill in impacted areas shall occur at a 1.5 to 1 ratio and shall follow the standards that are applicable to compensatory storage requirements described in this Manual.

10.3.3 Exceptions

Stream crossing structures meeting the conditions for sequencing and mitigation provided in Section 10.4 of this Manual are not required to mitigate for lost storage due to the limitations of working within a narrow corridor. Replacement of lost vegetation for stream crossing structures is not required at 1.5:1 ratio, but graded areas adjacent to the stream crossing should be revegetated with plant material compatible with the existing riparian area wherever possible.

10.4 Stream Crossings

10.4.1 Overview

There are a unique set of circumstances that apply to the construction of stream crossing structures within the floodplain or floodprone area. Stream crossing structures are for the purpose of conveying pedestrians, motor vehicles, and/or utilities across drainageways, which requires that they cross floodplain or floodprone areas perpendicular to the flow of water. In many cases it may be infeasible to build stream crossing structures in the floodplain or floodprone area in such a way as to offset all impacts to flood storage, conveyance, and the minimum flood corridor. In some cases, these standards do not have as great an application to stream crossing structures. Considerations for allowing certain exceptions for stream crossing structures include:

- It may be structurally or financially infeasible to construct new culverts or bridges for stream crossings in the floodplain or floodprone area outside the floodway without causing a rise in flood heights greater than 0.05 feet.
- It is difficult to apply the compensatory storage standard to stream crossings, because the impact at the crossing relates to the conveyance of water along the stream channel and flood storage is not as relevant to stream crossing structures as it is to parallel encroachments.
- While flood storage may be lost to fill and structural elements of the crossing, new stream crossing structures generally cause a rise in the water surface elevation behind the structure which increases flood storage.
- Fill from road crossings is typically minor compared to encroachments parallel to the channel.
- Alternatives for offsetting impacts are limited by the width of the stream crossing corridor and/or right-of-way.
- Major stream crossings which would be expected to have the greatest impacts are public structures which are typically subject to a higher environmental standard and review.

For stream crossing structures, a sequencing approach is required that seeks first to avoid, then minimize, then mitigate for any impacts to flood storage or flood heights. Certain exceptions are allowed in meeting the no net rise criteria, and loss of flood storage is not required to be mitigated within or outside of minimum flood corridors. Furthermore, stream crossing structures meeting the conditions for sequencing and mitigation provided in this section are not required to mitigate for lost vegetation within minimum flood corridors at 1.5:1 ratio, but graded areas adjacent to the stream crossing should be revegetated with plant material compatible with the minimum flood corridor wherever possible.

Structures in the floodway will need to continue to follow minimum federal floodplain standards per the City of Lincoln Municipal Code and follow drainage design criteria for hydraulic structures in this Manual.

10.4.2 Sequencing Criteria for Stream Crossing Structures

A sequencing approach that seeks first to avoid, then minimize, then mitigate for any impacts to flood storage or flood heights is required for all stream crossings within a floodplain or floodprone area. Documentation must be submitted to the City for review showing the steps taken using the sequencing approach and the selected alternative. Documentation is to include required information per Section 10.5 of this Chapter.

The sequencing process will include an evaluation of alternative approaches in the order listed below:

1. Avoidance. The project should seek to avoid stream crossings if there is a practicable alternative that does not cause increases in flood heights.
2. Minimization. If it is determined that avoidance is not practicable, steps must be taken to minimize impacts to the floodplain or floodprone area outside the floodway. (Note: Stream crossing structures must meet minimum federal standards by demonstrating that the project causes no rise (0.00 feet) in the floodway). The three alternatives below should be evaluated in sequence to minimize impacts to the floodplain or floodprone area outside the floodway. The first practicable approach which minimizes adverse impacts shall be selected:
 - i. An alternative that meets the 0.05 foot rise criterion.
 - ii. An alternative that causes no more than a 0.5 foot rise.
 - iii. An alternative that causes no greater than 1.0 foot rise.

3. Mitigation: If avoidance is not practicable, impacts to the floodplain or floodprone area shall be mitigated in conformance with Section 10.4.3 after an appropriate and feasible alternative has been chosen through minimization.

The City's review and approval of the alternative selected will be based upon whether best efforts were made to find a practicable alternative with the least impacts. The City may consider whether another practicable alternative with less adverse impact on the floodplain and floodprone area is feasible. For County stream crossings, the City and County will jointly determine the most appropriate alternative. If the proposed stream crossing structure does not meet the 0.05 foot rise standard, mitigation for increased flood heights will be required in conformance with section 10.4.3.

10.4.3 Mitigation

Mitigation is required for stream crossing structures causing increases in flood heights greater than 0.05 feet within the floodplain or floodprone area outside the floodway for the 100-year flood. Grading impacts to minimum flood corridors areas should be revegetated with plant material compatible with the minimum flood corridor wherever possible. Impacts to base flood elevations shall be mitigated and documented in accordance with the following:

1. Acquisition by land rights purchase, flowage easement, or other legal arrangement that runs with the property, of the right to increase the flood levels on all affected lands.
2. Documentation to include:
 - i. Complete hydraulic study with profiles for the stream crossing;
 - ii. Complete hydrologic study for the stream crossing as required per Section 10.5 in areas with watershed master plans, or if otherwise completed for the project;
 - iii. Pre-construction and post-construction base flood elevations for each parcel of land being impacted
 - iv. Legal documentation identifying acquisition of the right to increase the flood levels on all affected lands.
 - v. All other information as required by Section 10.5 of this Chapter.

10.4.4 Minimum Federal Standards

Notwithstanding the sequencing and mitigation approaches outlined above, all projects must meet the minimum federal standards for FEMA-mapped floodways or flood fringe areas where no floodway has been designated, as described in Section 10.2.4.7, "Minimum Federal Standards."

10.5 Information Required

The following information shall be required for preliminary plats and development permits in floodplain and floodprone areas, and shall include plans and other information as appropriate related to:

1. Grading plan showing existing and proposed grades, base flood elevation, location of channel and hydraulic cross-sections, with elevations in NAVD 1988 datum;
2. Limits of floodway, floodplain or floodprone area, and minimum flood corridor;
3. The type and extent of the proposed use or development of the land which is located within the floodplain or floodprone area, along with such information as is necessary to determine the effect flood waters will have on such development and use and the effect such development may have upon the flood waters. All

such information shall show the location of the proposed use, areas of habitation and employment, including the location, size, and floor elevation of any structures, the location and elevation of all parking areas, and the use, location, and elevations of all open land areas.

4. Hydraulic cross sections, profiles, and summary report;
5. In areas with no watershed master plans, existing and proposed water surface elevations for the 100-year flood event;
6. In areas with watershed master plans, existing and proposed water surface elevations for the 2-, 10-, and 100-year flood event;
7. If the proposed development is in the floodway, information, documentation and certification by a registered professional engineer demonstrating the development will cause no rise in the flood elevation as required by Section 10.2 of this Manual;
8. If the proposed development is in the floodplain or floodprone area outside the floodway, information, documentation and certification by a registered professional engineer demonstrating the development will not result in any increase in the 100-year flood elevation greater than five hundredths of a foot (0.05') of rise in as required by Section 10.2 of this Manual;
9. The amount of fill material brought into the floodplain or floodprone area from outside the floodplain or floodprone area and locations and volumes of cut and fill within the floodplain or floodprone area;
10. Locations of compensatory storage, and all information and certification by a registered professional engineer demonstrating that compensatory storage is hydrologically equivalent as required by Section 10.2 of this Manual;
11. In areas with watershed master plans, a hydrologic study and report using the master plan modeling that includes existing and proposed curve numbers, time of concentrations, areas, schematics, and other narrative information as appropriate;
12. Sequencing information for encroachments into minimum flood corridors as required by Section 10.3 of this Manual;
13. Sequencing information for stream crossing structures as required by Section 10.4 of this Manual.

The following additional information shall be required for preliminary plats and development permits in Zone A floodplain areas (no base flood elevations determined) when the proposed development is greater than either five acres or fifty lots:

1. Detailed base flood elevation data based on an engineering study performed by a qualified engineer in accordance with FEMA approved methods for generating detailed base flood elevations.
2. Hydrologic and hydraulic methodology to include:
 - i. Hydrologic modeling completed using a FEMA approved method. The latest version of HEC-HMS is recommended. Regional regression equations will not be allowed for preliminary plats and development permits.
 - ii. The 100-year water surface elevations generated using a FEMA approved method. The use of the latest version of HEC-RAS is recommended.

3. Required data sets, consistent with FEMA’s Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C: Guidance for Riverine Flooding Analyses and Mapping, to include but not limited to:
 - i. Discharges for existing and proposed conditions including the 100-year flows. 10-year flows are also to be included when evaluated for compensatory storage without a hydrologic study.
 - ii. Flood profiles for the 10- and 100-year flows referenced to the NAVD 1988 datum.
 - iii. Cross sections and locations.

Additional information not listed in Appendix C: Guidance for Riverine Flooding Analysis and Mapping:

- i. Limits of the 100-year flood event.
- ii. Digital copy of the hydraulic model.

10.6 Additional Recommended Flood Design Criteria

10.6.1 Overview

Development in the floodplain or floodprone area is strongly encouraged to incorporate one of more of the practices outlined below, which are voluntary standards that exceed the minimum design criteria. Best Management Practices (BMPs) such as grassed swales, water quality wetlands, stormwater retention cells, and better site design can offset impacts to the natural and beneficial functions of floodplains and floodprone areas when they are implemented. Where noted, additional information for some practices is provided in Chapter 8 of this Manual. Further information on these and other BMPs can also be found at the Center for Watershed Protection and Environmental Protection Agency (EPA) websites.

10.6.2 Cluster Development

Cluster development is a site design technique that can facilitate the preservation of floodplain or floodprone areas. Also known as open space design or conservation development, cluster development concentrates dwelling units in a compact area in one portion of the site while keeping other portions of the site in open space (see Figure 10-3 ref. National Association of Home Builders website, topic open space/cluster development). According to the National Association of Home Builders website, “this methods allows the most scenic or sensitive land (forest, wetlands) to be preserved while protecting the rights of the land owner to develop the land....Experience has shown that many home buyers will pay just as much for smaller lots when they are near protected open space. Studies have shown that homes near open space appreciate faster that similar homes not near open space.”

Preservation of the 100-year floodplain or floodprone area preserves the flood conveyance and storage characteristics and other natural and beneficial functions by allowing floodwaters to spread over large areas, which reduces velocities and flood flows downstream. Natural vegetation acts as a filter for pollutants, stabilizes soils and provides wildlife habitat. If these natural functions are eliminated or impacted during the development process, it can result in costs for facilities and/or maintenance obligations that would otherwise not have been needed.

Cluster development protects open space by consolidating the buildings onto smaller lots adjacent to the preserved floodplain or open space. Thus, residential developments can be designed to protect floodplain or floodprone areas without any loss in the total number of units. In Lincoln, residential cluster development is permitted through the Community Unit Plan (CUP) identified in Chapter 27.65 of the Lincoln Zoning Ordinance. Lincoln’s standards allow up to a 20% dwelling unit bonus for the protection of floodplain or floodprone areas in a CUP. There is also the potential to consolidate commercial space through the Planned Unit Development (PUD) process identified in Chapter 27.60 of the Lincoln Zoning Ordinance.

A secondary benefit to cluster development is that it can minimize the infrastructure, development costs, and maintenance required by conventionally designed subdivisions. This can include:

- reduced grading
- reduced linear feet of streets, sidewalks, and utilities
- reduced stormwater runoff
- reduced vegetative maintenance
- reduced lawn water usage
- reduced phosphorus and nitrogen loads

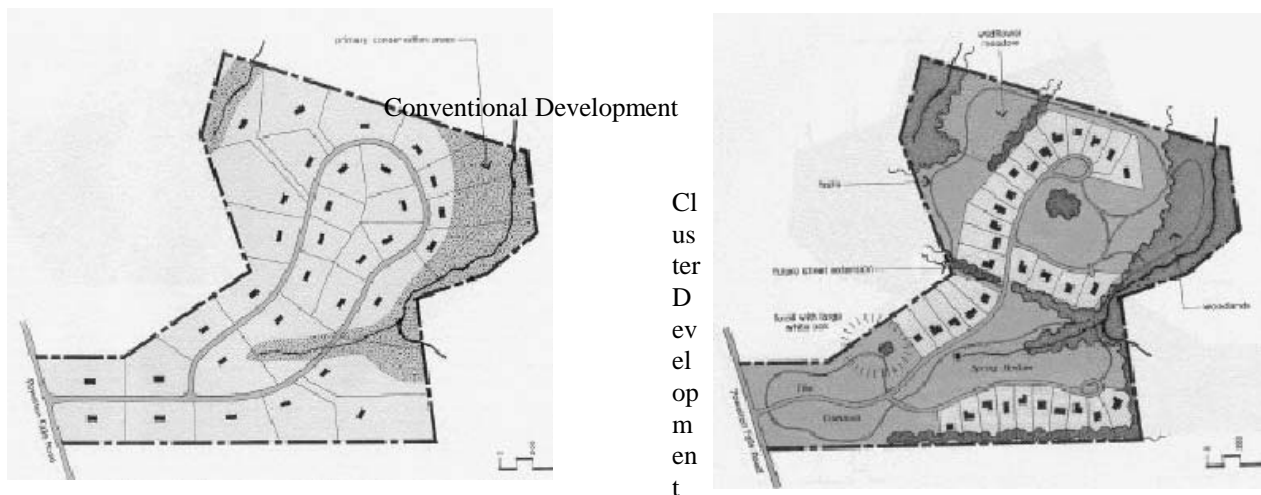


Figure 10-3
Conventional and Cluster Development

10.6.3 Conservation Easements

A conservation easement is a tool that can be used to permanently protect floodplain or floodprone areas. A permanent conservation easement is required for the protection of floodplain or floodprone areas in order to receive the dwelling unit bonus provided through a Community Unit Plan as described in the section above. A conservation easement is a set of restrictions placed on a property in order to preserve its conservation values. The conservation

values of the property and the restrictions created to preserve those values, along with the rights reserved by the landowner, are detailed in a legal document known as a conservation easement agreement. This document is filed with the entity which accepts the easement, which may be the city, county, natural resources district, or a private conservation organization. A permanent conservation easement runs with the property and applies to the current owner as well as all future landowners to permanently protect the property. The donation of a conservation easement under certain circumstances may allow the landowner to claim a federal income tax deduction for the value of the easement, and insofar as a permanent conservation easement reduces the value of the land, it has the potential to result in reduced annual property taxes.

10.6.4 Constructed Wetlands and Other Water Quality Best Management Practices

In brief, a constructed wetland or other water quality Best Management Practice (BMP) is a water treatment facility. Development and associated urbanization generally increases impervious surfaces and decreases vegetation that acts as a filter for pollutants. Pollutants typically found in urban runoff include sediment, nutrients, heavy metals, and bacteria. Water quality BMPs filter stormwater runoff and remove harmful pollutants.

Development is encouraged to mitigate the impact of urbanization on stream water quality through the construction of wetlands or other water quality BMPs. The location of the water quality BMPs is critical to the effectiveness of these facilities for treating runoff. The optimal site for water quality BMPs is at the low end of the drainage basin in order to capture and filter stormwater from the majority of the site.

10.6.4.1 Criteria

Water quality BMP's should be designed and constructed based upon the watershed area draining to the site and should provide detention for 24 hours. The treatment volume for the wetland or other water quality BMP (or the combined treatment volume from a combination of water quality BMP's) should equal or exceed that needed for the initial 1/2 inch of stormwater runoff per impervious acre of the development site.

Acceptable models, with the exception of the Rational Method, for modeling stormwater runoff are listed in Chapter 2 of this Manual. The Rational Method should not be used for modeling stormwater runoff and volume for water quality BMPs.

A constructed wetland is a specific water quality BMP which is designed to duplicate the processes occurring in natural wetlands to create complex, integrated systems in which water, plants, animals, microorganisms and the environment--sun, soil, air--interact to improve water quality. If properly built, maintained and operated, constructed wetlands can effectively remove many pollutants associated with municipal and industrial wastewater and stormwater. Such systems are especially efficient at removing contaminants such as BOD, suspended solids, nitrogen, phosphorus, hydrocarbons, and even metals. These wetlands thrive best when stockpiled soils removed from mitigated wetlands are incorporated into the new site. In the Lincoln area, wetlands may be either freshwater or saline.

For constructed wetlands, Section 8.3.4.3 of this manual should be consulted for detailed design criteria.

10.6.4.2 Plant Lists

Supplemental information regarding plant materials for constructed wetlands is listed below. Plant mix lists are referenced from the 2003 publication “A Guide to Prairie and Wetland Restoration in Eastern Nebraska” produced by the Prairie Plains Resource Institute and the Nebraska Game and Parks Commission. The planting lists can be used as a guide if material is not available from a wetland topsoil stock pile.

| <u>Rainwater Basin/Freshwater Marsh Mix</u> | | | |
|--|------------------------------|-------------------------------------|---------------------------------------|
| <u>Common Water Plantain</u> | <u>Alisma</u> | <u>Rice Cutgrass</u> | <u>Leersia oryzoides</u> |
| <u>subcordatum</u> | (including <u>A.</u> | | |
| <u>triviale</u>) | | | |
| <u>Swamp Milkweed</u> | <u>Asclepias incarnata</u> | <u>Stiff Arrowhead</u> | <u>Sagittaria rigida</u> |
| <u>Nodding Bur-marigold</u> | <u>Bidern cernua</u> | <u>Short-beak Arrowhead</u> | <u>Sagittaria brevirostra</u> |
| <u>Common Beggar-tick</u> | <u>Bidens</u> | <u>Thick-stalk Arrowhead</u> | <u>Sagittaria calycina</u> |
| <u>frondosa</u> | | | |
| <u>Common Spikerush</u> | <u>Eleocharis palustris</u> | <u>Common Arrowhead</u> | <u>Sagittaria latifolia</u> |
| | (<u>E.marcostachya</u>) | | |
| <u>False Nettle</u> | <u>Boehmeria cylindrica</u> | <u>Hard-stem Bulrush</u> | <u>Schoenoplectus acutus</u> |
| | | | (<u>Scirpus a.</u>) |
| <u>Emory’s Sedge</u> | <u>Carex emoryi</u> | <u>Three-square Bulrush</u> | <u>Schoenoplectus pungens</u> |
| | | | (<u>Scirpus p.</u>) |
| <u>Bottlebrush Sedge</u> | <u>Carex</u> | <u>Soft-stem Bulrush</u> | <u>Schoenoplectus tabernaemontani</u> |
| <u>hystericina</u> | | | |
| <u>Bald Spikerush</u> | <u>Elocharis erythropoda</u> | <u>Pale Bulrush</u> | <u>Scirpus pallidus</u> |
| <u>Tall Manna Grass</u> | <u>Glyceria grandis</u> | <u>Large-fruit Bur-reed</u> | <u>Sparganium eurycarpum</u> |
| <u>Orange Jewelweed</u> | <u>Impatiens capensis</u> | | |

The Rain Basin/Freshwater mix is mostly suitable for planting within stream and river floodplains in eastern Nebraska. The list contains mostly perennial species. The seeds are typically hand broadcast at a rate of 1-2 gallons per acre.

| <u>Saline Wetland Mix</u> | | | |
|------------------------------------|--------------------------------|----------------------------------|---------------------------|
| <u>Silver Orach</u> | <u>Atriplex argentea</u> | <u>Annual Marsh-elder</u> | <u>Iva annua</u> |
| <u>Saltmarsh Spearscale</u> | <u>Atriplex dioica</u> | <u>Plains Bluegrass</u> | <u>Poa arida</u> |
| | (<u>A. Subspicata</u>) | | |
| <u>Saltmarsh Bulrush</u> | <u>Bolboschoenus maritimus</u> | <u>Saltwort</u> | <u>Salicornia rubra</u> |
| <u>Short-beak Sedge</u> | <u>Carex</u> | <u>Prairie Cordgrass</u> | <u>Spartina pectinata</u> |
| <u>breivor</u> | | | |

| | | | |
|----------------------------------|--|-------------------------------|--|
| <u>Inland Salt Grass</u> | <u>Distichlis spicata var. stricta</u> | <u>Sea Blite</u> | <u>Suaeda caleoliformis (S. depressa)</u> |
| <u>Western Wheatgrass</u> | <u>Elymus smithii (Agropyron s.)</u> | <u>Saltmarsh Aster</u> | <u>Symphytotrichum subulatum (Aster subulatus)</u> |
| <u>Foxtail Barley</u> | <u>Hordeum jabatum</u> | | |

The saline wetland mix is suitable for planting in saline wetlands within the floodplains of Salt Creek and its tributaries in Lancaster and southern Saunders counties. Few plant species can grow on the highly saline, clay soils of these wetlands and therefore a low diversity seed mix is appropriate. This mix includes both perennial and annual species. Salt flats, areas with standing water in the spring that dry in the summer leaving salt crusts, are extremely harsh growing environments for most species. Saltwort is an endangered plant in Nebraska and a permit from the Nebraska Game and Parks Commission is required prior to collecting its seed. Saltgrass, a dominant plant in most saline wetlands, rarely produces visible seed. The seed mix for this community should be broadcast at a rate of about 7 gallons per acre.

10.6.4.3 Additional Information

Guidelines related to plan review, ownership and maintenance, grading and depth, outlets, downstream analysis, design, construction and maintenance considerations, protective treatment, and trash racks and safety grates should be followed for water quality BMP's in a similar manner to what is shown in Chapter 6 of this manual for storage facilities. Plans for water quality BMPs in floodplains and floodprone areas should also be accompanied by calculations showing the impact to flood storage and flood heights and other information in conformance with the required standards of this chapter.

10.6.5 Filter Strips

Vegetative filter strips capture sediment and organic material by slowing runoff water leaving a field. As water is slowed, larger soil and organic particles rapidly settle out. Smaller clay particles need a longer flow distance to settle out in the filter. Therefore, a larger strip width is needed for removing finer soils. Filter strips work best when water flows at a shallow uniform depth across the filter. If water becomes concentrated in small channels, the effectiveness of the strip is drastically reduced. Filter strips also work best on relatively flat slopes. Details on this BMP are provided in Section 8.3.4.5 of this Manual.

10.6.6 Grassed Swales

Grassed swales are vegetated water conveyance systems that can improve stormwater quality through infiltration and filtering. Swales can use a natural drainage features or be constructed. Grassed swales are designed to treat stormwater quality and volume and to provide stable flows during a storm event. Typically, tall rigid grasses with extensive root systems are desirable. Details on this BMP are provided in Section 8.3.4.4 of this Manual.

10.6.7 Porous Pavement

Porous pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil. This porous surface replaces traditional pavement, allowing parking lot runoff to infiltrate directly into the soil and receive water quality treatment. There are several pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous grid systems with

open areas designed to allow grass to grow within the void areas. Details on this BMP are provided in Section 8.3.4.8 of this Manual.

10.6.8 Stream Buffers

Natural boundaries between local waterways and development are referred to as stream buffers. These vegetated buffers protect water quality by filtering pollutants, sediment, and nutrients from runoff. Other benefits of buffers include flood control, stream bank stabilization, stream temperature control, and room for lateral movement of the stream channel. A buffer called a Minimum Flood Corridor is required along all stream channels which drain at least 150 acres or have a defined bed and bank (see Section 10.3 of this Manual). However, this section describes additional design practices that exceed the minimum standards which are encouraged for optimal stormwater treatment.

For optimal storm water treatment, a stream buffer should be composed of three lateral zones: a storm water depression area that leads to a grass filter strip, which in turn leads to a forested buffer. Buffers can be applied to new development by establishing specific preservation areas and sustaining management through easements or community associations.

10.6.8.1 Siting and Design Considerations

In general, a minimum base width of at least 100 feet is recommended to provide adequate stream protection. The three-zone buffer system, consisting of inner (Zone 1), middle (Zone 2), and outer (Zone 3) zones, is an effective technique for maximizing buffer effectiveness (See Figure 10-4 ref. University of Nebraska Cooperative Extension website, topic conservation buffers). The zones are distinguished by function, width, vegetative target, and allowable uses, as follows:

1. The **outer zone** functions to prevent encroachment and filter backyard runoff. The width is at least 25 feet and, while forest is encouraged, turfgrass can be a vegetative target. In the outer zone, a stormwater depression is designed to capture and store stormwater during smaller storm events and bypass larger stormflows directly into a channel. Non-structural uses for the outer zone are unrestricted and can include lawn, garden, compost, yard wastes, and most storm water BMPs.
2. The **middle zone** provides distance between upland development and the inner zone and is typically 50 to 100 feet, depending on stream order, slope, and 100-year floodplain/floodprone areas. In the middle zone, the captured runoff within the stormwater depression is spread across a grass filter designed for sheetflow conditions for the water quality storm. The vegetative target for this zone is managed forest, and usage is restricted to some recreational uses, some stormwater BMPs, and bike paths.
3. The **inner zone** protects physical and ecological integrity and is a minimum of 25 feet plus wetland and critical habitats. In the inner zone, the grass filter discharges into a wider forest buffer designed to have zero discharge of surface runoff to the stream (i.e., full infiltration of sheetflow). The vegetative target consists of mature forest, and allowable uses are very restricted (flood controls, utility right-of-ways, footpaths, etc.).

Stream buffers are encouraged to be carefully designed in order to satisfy the conditions identified above. In particular, simple structures are needed to store, split, and spread surface runoff within the stormwater depression area. Consequently, it may be useful to consider elements of bioretention design for the first zone of an urban stream buffer (shallow ponding depths, partial underdrains, drop inlet bypass, etc).

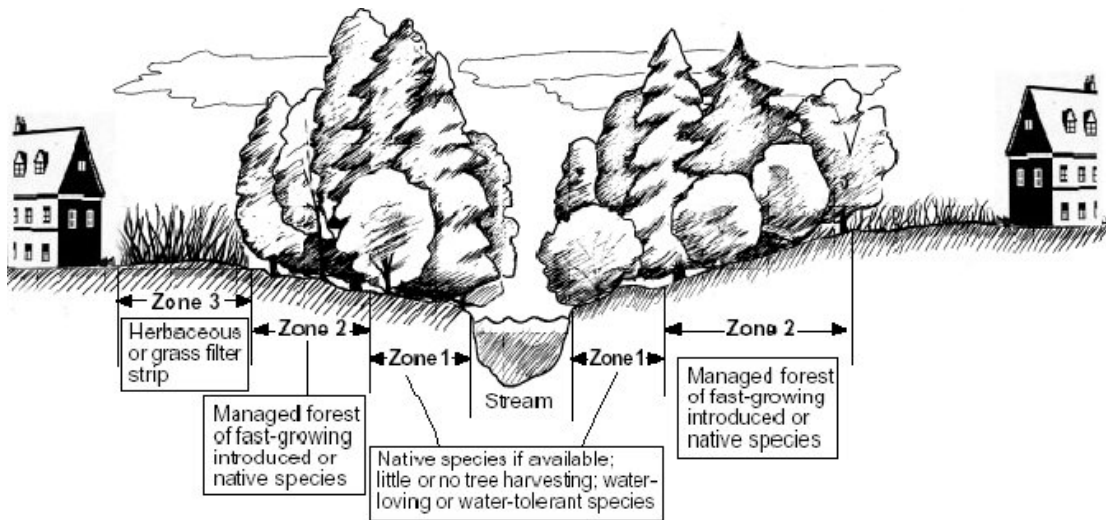


Figure 10-4

10.6.8.2 Maintenance Considerations

An effective buffer management plan should include establishment, management, and distinctions of allowed and unallowed uses in the buffer zones. Buffer boundaries should be well defined and visible before, during, and after construction. Without clear signs or markers defining the buffer, boundaries become invisible to contractors and residents. Buffers designed to capture stormwater runoff from urban areas may require more maintenance if the first zone is designated as a bioretention or other engineered depression area.

10.6.9 Development and Building Construction Practices

'Best Construction Practices' relating to both site development and construction are strongly encouraged and include the following approaches:

- For non-residential development, limit fill placement for the purposes of elevating proposed structures to the minimum building pad area required to accommodate the proposed structure and associated utilities.
- Site structures in a way that minimizes the impediment to flow created by the structure and the susceptibility of the structure to debris damage. This can generally be achieved by placing sections of the structure with greater length parallel to the flow path of flooding.
- For non-residential construction, use flood proofing methods to reduce the need for site fill and associated volumetric displacement of flood storage.
- Preserve natural vegetation on building sites whenever possible. Land disturbance should take place only where necessary to prepare the site for construction, and care should be taken to avoid disturbance of those areas on site where no construction or development is proposed. Project phasing and sequencing should be utilized to minimize floodplain or floodprone area land disturbance whenever possible.

10.6.10 Stream Stability Criteria

10.6.10.1 Overview

Development and associated urbanization generally increases impervious surfaces. This in turn increases the speed at which runoff reaches streams, and thus the amount and rate of flow in the receiving stream. The impact to existing receiving streams can be mitigated by the construction of stream stability measures.

10.6.10.2 Criteria

Impacts to stream stability caused by development should be evaluated for the 1-, 2- and 5-year storm events based upon the erosion potential of the proposed flow. Detailed guidelines for evaluating the impact of increased flows can be found in pages 84-92 of the Southeast Upper Salt Creek Watershed Stormwater Master Plan, dated October 2003. Figure 10-5 below from the Master Plan can be utilized in conjunction with soil information from the Lancaster County Soil Survey to select correction factors for flow depth, sediment concentration, flow frequency, channel curvature, bank slope, and channel boundary soil properties. Selection of stream management alternatives to mitigate impacts to stream stability should be guided by the use of professionally accepted and widely used stream classification and restoration methods such as the Rosgen and NRCS methods outlined in the Master Plan.

Flood Design Criteria for New Growth Areas

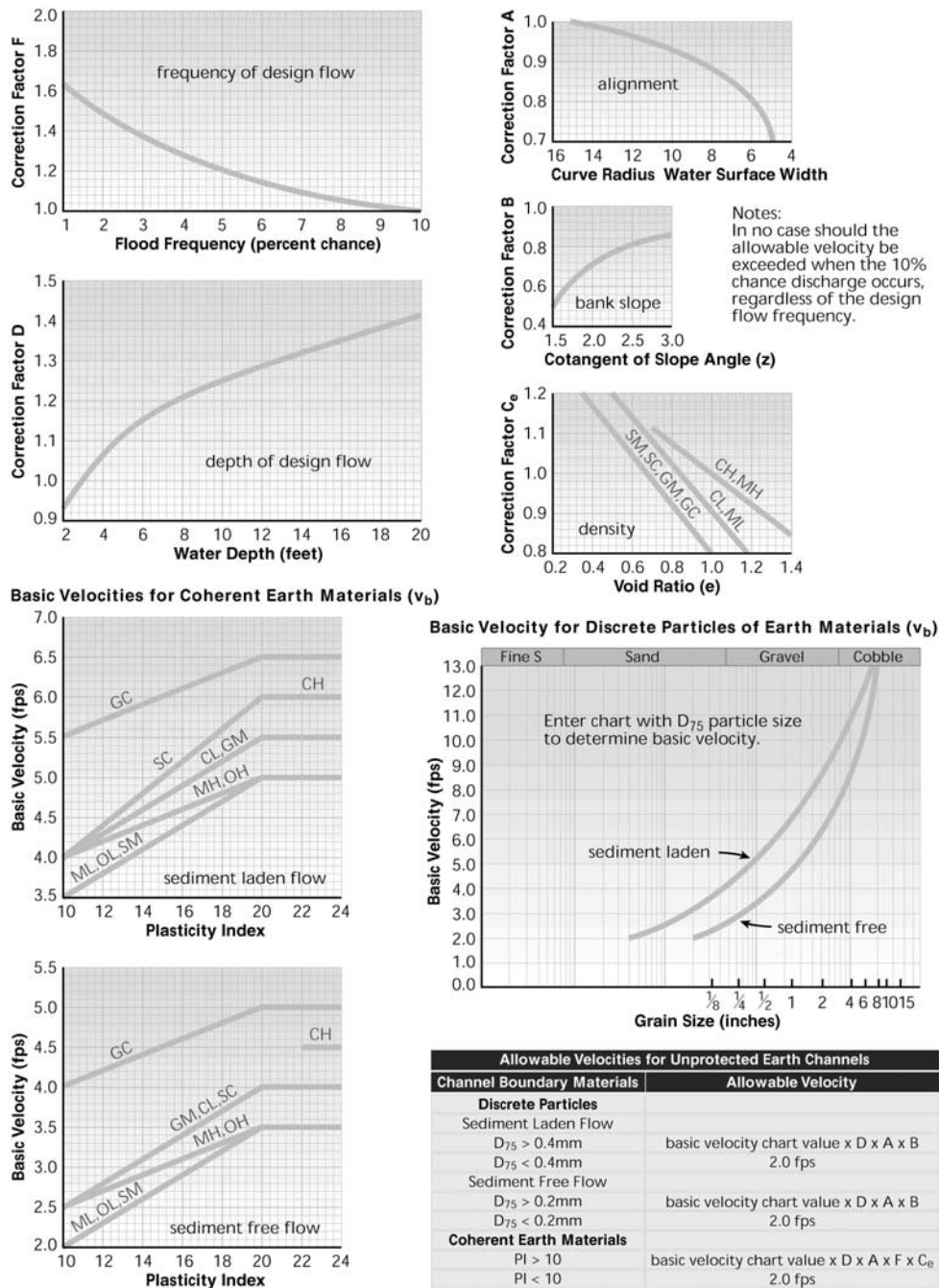


Fig. 8.31 -- Allowable velocities for unprotected earth channels. Curves reflect practical experience in design of stable earth channels.
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

Figure 10-5 from Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG).

The U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) should be utilized for modeling stream channel hydraulics. Other models need to be approved by the City of Lincoln Public Works and Utilities Department.

10.6.10.3 Additional Information

Additional design guidelines and construction and maintenance considerations for stream stability projects are listed in Chapter 5 of this Manual. Appropriate soil investigation information and supporting calculations for hydraulic analysis and design should be submitted to PW/U for review and approval. Supporting calculations should include design storm inflow and outflow hydrographs, stage-storage-discharge curves, and cumulative inflow-outflow elevation curves for the design storms. Plans for stream stability measures should also be accompanied by calculations showing the impact to flood storage and flood heights and other information in conformance with the required standards of this chapter.

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